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October 23-24, 2003

Inn and Conference Center, University of Maryland
College Park, MD

MEETING REPORT

Paul Hertz	**Edward W. Kolb**
Executive Secretary	**Chair**

STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE (SEUS)
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MEETING MINUTES

TABLE OF CONTENTS

Meeting Report Prepared By:
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October 23, 2003-Joint SEUS/OS Session

Introduction

Dr. Paul Hertz, Executive Secretary of the Structure and Evolution of the Universe Subcommittee (SEUS), welcomed members and presented the particulars of the agenda and rules of engagement, reminding members that this is a public meeting with a number of non-committee members present. Minutes and subcommittee letters will be posted on the web: http://spacescience.nasa.gov/. Presentations will be posted at http://spacescience.nasa.gov/admin/divisions/sz/SEUS0310/.

Mr. Alphonso Diaz, Director of Goddard Space Flight Center, offered brief remarks focusing on the NASA mission to inspire the next generation of explorers. Mr. Diaz encouraged members to continue to work with NASA to ensure that the Enterprise survives.

Astronomy and Physics (A&P) Overview

Dr. Anne Kinney, Director, Astronomy and Physics Division (APD) presented the highlights of the Space Infrared Telescope Facility (SIRTF) launch. SIRTF is now cold and performing better than the models had predicted- all modes are operating on all instruments. A SIRTF test graphic was shown; this was not a First Light graphic but still represented good news. Currently, SIRTF is in-orbit checkout and is proceeding as planned. This has been an extremely well managed program, an example of how to manage a mission. If all goes well, a December 18 news announcement will be made. Performance thus far has been generally flawless. Gravity Probe B (GP-B) has been delivered to Vandenburg Air Force Base in preparation for launch on December 6, 2003. The APD has had two of its largest future missions move from phase A to B- the James Webb Space Telescope (JWST) and SIM. JWST has selected a beryllium-based primary mirror. The APD is also trying to get the word out on newsworthy science and is working closely with the scientists to disseminate exciting science news. There have been 11 Space Science Updates (SSU's) in the last year. APD is also about to begin two major missions from the Beyond Einstein (BE) initiative. The year 2003 has also seen the successful launch of CHIPS and Galaxy Evolution Explorer (GALEX), as well as the Spirit and Opportunity Mars launches (due for a January-February 2004 landing). GP-B, SWIFT, and CINDI are to launch later this year or next year.

The February 11 "baby picture" of the universe from WMAP was a great highlight. An RXTE SSU demonstrated a measurement of a "cosmic speed limit" on pulsars. Hubble provided a view of the oldest known planet. Chandra captured sound waves from black hole; this event was covered in Billboard magazine and in many other media including the New York Times and the Washington Post. The operating mission status was briefly reviewed. Basically all are up and operating with a green status. SEU has some yellows and reds but is mostly green. Minor problems with gyros have been experienced on GP-B, however most concerns have to do with launch vehicles. There is some helium leakage in the Astro-E2 dewar. Herschel and Planck have some eroding reserve issues. A bilateral meeting is to be held on October 27 with the European Space Agency (ESA). In the Origins theme, the best news has been SIRTF. The Hubble Space Telescope Servicing Mission 4 (HST SM4) is a bit of a concern with the loss of the shuttle, and this remains a significant issue. Eight shuttle missions are required for core complete for the International Space Station (ISS), and the absence of shuttle availability may adversely impact future Hubble servicing missions. In the SOFIA mission there are still problems with a 747 door. The FAA is looking closely at the problem. Keck is going well, but legal issues continue to plague this project over the issue of possible future interferometers in the form of outriggers. The LBTI mission is coded as green. Kepler has no major issues. SIM reached a major technology goal recently and APD is still very optimistic. The JWST mission is preparing for an SRR in December. Overall budgets for FY04 were briefly presented. Positive A&P budget trends are the result of successful science articulation. Dr. Edward Weiler, Associate Administrator for Space Science, was credited with much of this success. FY04 new content for the Office of Space Science includes the Jupiter Icy Moons Orbiter (JIMO) and Project Prometheus, and an optical communications program for revolutionary data transmission technology. LISA and Constellation-X are now real programs. Current issues are the launch of GP-B; delays cost $4M per month. The funding source for the delay has not been identified. The Swift launch has also been delayed. The division continues to grapple issues surrounding the Einstein Probes and SM4.

In response to a question, Dr. Kinney stated that the GP-B is highly likely to launch in December. The primary open issue on GP-B was the failed thermal vacuum test. Dr. Kinney called a technology and scientific review earlier this year, an action that attracted a lot of attention. Part of this review called for criteria for passing thermal vacuum and has not been signed off yet. The other concern was the absence of a post-launch operations plan. R&A is expected to grow through FY06, by inflation. Costs for new projects will include all civil servant costs (Full Cost Accounting; FCA). Shuttle costs are currently carried in code M. Any potential shuttle future launch costs may reside in code S.

NASA Response to HST-JWST Transition Report

Dr. Kinney presented the division response to the transition report. One of the main recommendations of the reports was to hold a fair and open competition for SM-5. This has consequences for the community and the rest of the codes. APD takes into account Decadal Reports and Roadmaps. The Columbia Accident Investigation Board (CAIB) report and the Return to Flight effort will play an important role in APD's future. APD is the recipient of these decisions and cannot influence the outcome. One of the important ongoing studies concerns the HST de-orbit options. The shuttle is no longer an option and APD is now considering upper stage options to bring it down. The Transition Review Panel also evaluated the transition plan and issued a widely distributed report. The Black panel also reviewed the scientific potential of a reduced HST mission, however the panel was unable to reach consensus on the value of an SM5. The end-of-mission concepts charter includes an evaluation of adding an upper stage propulsion system. An upper stage is not viable in the current design iteration. Projected costs ($300M) do not include a launch vehicle. The Bahcall report identified as its highest priority option a scenario involving two more servicing missions in 2005 and 2010. If there are to be no further servicing missions, cutting-edge science at reduced capability should be performed for as long as possible, after which a robotic mission should be performed to bring down HST in a controlled descent. Deep field observations remain powerful in this scenario.

NASA assessment has resulted in a draft scenario for an SM5 competition, studies of de-orbit strategies, and enabling HST operation in degraded capability scenario. Principles of servicing must address the safety of astronauts, the safety of HST, and the inherent science value of the mission. The proposed competition would be similar to a scientific investigation solicitation. Funding sources would depend on the nature of the winning science. Such a competition would provide the opportunity to revisit and reorder the Office of Space Science (OSS) science plan outside of the normal strategic cycle. It would entail significant funding reallocation, and require approval from Dr. Weiler, Administrator Sean O'Keefe, OMB, and Congress. If an SM5 is selected, implications for OSS include the possibility that Explorer/Discovery lines may be halted for 5 years during the development, or funded at some reduced level in operational years. In addition there is a potential for the reordering of OSS strategy, scientific theme balance, and programmatic lines. APD has also tried to respond to previous advice from the decadal plans in the response to these panels. The APD wants to complete an SM4 and safely de-orbit HST after useful science ceases. The rationale of the plan is to maintain vitality of program, follow past strategic advice, and take into account the large cost of an SM5 as well as Return to Flight activities.

In response to questions from the committee, Dr. Kinney explained that competition of like versus like science investigations would be competed in different communities under one Announcement of Opportunity (AO). The winner would have to devise a mission that included as much science as possible. Proposals for SM5 versus Explorer missions would be categorized by science. This would be equivalent to a competition for Explorer science with $1.2 B cost cap. A committee member asked whether it would be more valuable to have one high-cost mission competed in this way rather than in small chunks competed serially over 6 years. This would change the Explorer line; one would give up small and medium missions in favor of a large mission. Discussion ensued about the prohibitively high cost of a mission that would only nominally decrease the likelihood of casualties on Earth. Dr. Kinney commented that APD science is discretionary and that the real problem is the chance that HST will land in a populated area. A committee member expressed concern that NASA is making a decision on a moving target (depending on Return to Flight). A de-orbit cannot be done with an SM5. Dr. Kinney replied that APD will develop an autonomous model as a backup scenario due to the rolling shuttle schedule. APD must develop some concept for SM5 in this case. A Space Plane cannot perform HST servicing. The urgency for making the decision comes from the cost accounting that indicates an SM5 should be ready by the end of the decade. HST cannot have a controlled de-orbit today; it must have a propulsion module. The cost of SM5 is a facility class mission level. It was observed that relying on a shuttle for a potential SM5 would be too risky. A member suggested that Dr. Kinney go to OMB and Congress and ask for new money. Dr. Kinney noted that option would have to come from the science advisory committees. If the suggestion were contained in a letter, that would be an option. SM5 did not appear in the OSS strategic plan. One part of one theme is strongly advocating an SM5.

Dr. Kinney further explained that safety considerations are driven by international agreements, government and NASA regulations that require HST to be de-orbited in a controlled manner. A committee member commented on the possibility of using an autonomous vehicle to push HST up to 800 miles, but Dr. Kinney replied that this altitude violates debris mitigation orbits, leaving a problem for NASA to solve in 100 years. A member, commenting as a scientist with an HST instrument, did not believe that an SM5 would be selected against competing missions, and instead suggested NASA optimize what it could do with SM4. An HST scientist commented that NASA should maintain flexibility. Dr. Hertz commented on the dubious contention that a AO could be formulated within 5 to 6 months- a $1B project cannot get off the ground in 5 months.

<u>HST Science from Servicing Mission 4</u>

Dr. Dave Leckrone, HST Project Scientist, presented an overview of the SM4 servicing mission. For planning purposes, a launch is assumed for December 2005, which is perhaps optimistic. The manifest includes plans for installing a COS and Wide Field Camera 3 (WFC3), replacing batteries, installing 3 new gyros, servicing the FGS and ASCS, installing MLI repair kits, and performing a re-boost to a higher orbit. The final payload may differ depending on new safety procedures or new HST needs. No corners will be cut on shuttle safety, and HST will go dormant if necessary. If Hubble fails irretrievably, NASA will accept this. The successful installation of COS will provide the most sensitive UV spectrographic system ever flown in space. It will study Lyman-alpha absorptions, formation of galaxies, chemical evolution of galaxies, etc. The design of the COS was briefly delineated. It has two channels to provide low and medium resolution UV spectroscopy and has both near- and far-UV capabilities. It will be the last bastion of space-based UV spectroscopy for a long time. The instrument has been assembled and tested at Goddard Space Flight Center (GSFC). COS versus STIS performance in the FUV was compared. COS is a point-source spectrograph and is an incomplete substitute for STIS; NASA will still lose important capabilities when STIS is out of service. The parameters of the WFC3 were presented. It is uniquely capable in the near-UV, unmatched by any other planned mission. It will study star formation, chemical enrichment, Lyman-alpha dropouts at $z = 1\text{-}2$, and will probe one of the darkest spectral regions in the sky. Its wavelength range is 200-1000 nanometers, based on a 4K x 4K CCD mosaic design; has a 1-2+ magnitude advantage over WFC2 in the near-UV, with better spatial sampling than PC. The near-infrared (NIR) channel will study high redshift galaxy formation, sources of cosmic re-ionization, and water and ices in the solar system. Hot pixel availability is expected to be better than with previous CCD's. Thus far, hot pixel tests have been performed at higher than normal operating temperatures, but cooler operation of the ASCS is expected to mitigate the hot pixel coverage on the WFC3. In addition,WFC3's charge-transfer efficiency (CTE) is expected to be significantly superior to that of the WFC2.

Factors affecting HST longevity were summarized. By December 2005, there will be a 50-50 chance of having only 3 gyros aboard the HST in operation. Battery tests indicate that each battery is degrading at an increasing rate. Cells will exceed their expected discharge cycle lifetimes in early 2005. Aggregate loss of capacity may require power management at some time in 2005 (losing one cell in one battery will definitely degrade the science return of the mission). Loss of two batteries may cause irretrievable loss of HST. Even if solar power is present (in terms of solar orientation of the HST), the batteries may fail. One fine guidance sensor (FGS2) is behaving anomalously at present and may fail. Two operational FGS's allow normal science operations but with reduced guide star availability, affecting about 10% of targets. If damage were limited, SM4 would proceed, however SM4 would not proceed in the event of an irreversible failure. If there were an SM5, there would be further opportunity to replace FGS's. HST serves a community of 3200 individuals; SM4 would continue to serve this community well.

<u>HST Servicing Mission Cost and Risk</u>

Mr. Preston Burch, HST Program Manager, presented costs and risks associated with SM5. Baseline assumptions used for cost estimates are launch in December 2010, assuming an SM4 in December 2005 (giving a development period of 52 months), a normal full science program, GO's, GTO's, Hubble Fellows, and one new science instrument. HST instrument heritage is assumed for prime science instrument

(SI) development cost. A principal investigator (PI) science development team is included. Contingencies of 20-30% are assumed on SI costs and servicing mission development costs. Cost options and assumptions were summarized. Some options reduce the development period to 40 months, and assume both presence and absence of a new SI. Particulars of the baseline cost estimate were summarized in terms of both Full Cost Accounting (FCA) and former accounting practices, amounting to about $1.2B in real year dollars with FCA. Other options are less costly. If SM5 were simply to be a de-orbit mission, $110M per year is assumed for ongoing operations. In response to a comment that HST could not operate after a propulsion module is attached, Mr. Burch noted that the propulsion module problems have been mitigated.

Projected costs do not reflect launch vehicle costs, de-orbiting activities, or a propulsion module. The cost of the de-orbit module would be about $100M. A member commented that this cost is closer to $300M if deployed on an expendable launch vehicle (ELV). Mr. Mike Moore noted that shuttle-transported stages are not inexpensive. Option 1 is the most austere and does not assume a new SI. Option 1 also assumes that only half the instruments are operational, and covers science operations for three years. The total cost in real year dollars is $654M. Options 2, 3 and 4 add some options back in and become increasingly expensive. Option 3 is closest to the baseline cost ($929M). The hardware manifest was reviewed: 6 gyros, FGS, SSA transmitter, solid state recorder, fixed-head star tracker, crew aids and tools, reboost, and carriers for ORU and FSS. SM5 could perform 2 science missions with a propulsion module, but it would be a tight squeeze. Extravehicular activity (EVA) scenarios were reviewed. Risks include the EVA itself, flight hardware installed into HST, space support equipment, HST deployment, and servicing preparations. The approach to risk mitigation includes the deployment of a knowledgeable and experienced core team, and a thorough testing program. HST is considered a very robust program and employs the “lessons learned” philosophy.

Extending HST Science without Servicing

Dr. Steve Beckwith presented a discussion on the merits of extending HST lifetime without further servicing missions. There is a risk of SM4 not coming off at all, or more likely a considerable delay in SM4 deployment. By the beginning of 2006, 2 additional gyros (4 in total) may have experienced failure leaving only 2 gyros operational, fewer than the minimum number of 3 currently required for pointing. Two-gyro science is considered possible for about 15 months past the 4th gyro failure. Two-gyro mode will not recover the full science program. There may be no way to use a guide star system with two gyros. HST pointing control parameters were summarized. Jitter is controlled by 3 independent-axis gyroscopes. The gyro drift rates are very slow. If one gyro is lost, the axis without control would project into the focal plane, and increase the jitter up to about 50 mas (milliarcseconds). Images under 2-gyro control were presented for comparison. HRC is degraded, WFC is slightly degraded; broad slits are OK, narrow slits become problematic. Adverse science implications include the question of being able to acquire a guide star, telescope drift, and exposure time versus jitter effects. Lack of further servicing may have a small impact on WFC science. Diffraction-limited and high-contrast imaging will be severely compromised. Current surveys should be possible with 2-gyro control and the science program should remain largely intact. High-resolution imagery will suffer, however. The 2-gyro mode will compromise high-contrast and diffraction limited imaging, thus compromising HST future science. A 2-gyro mode is a prudent way to mitigate against delays in future HST service missions, but is not a substitute for 3-gyro operation.

There was some concern expressed about gravitational lensing studies (wide-field science), which would be adversely impacted by 2-gyro operation. The conclusion was the gravity studies would be harder but not impossible. The 2-gyro mode is projected to be available in April 2005.

HST Proposal Module Studies

Mr. Mike Moore gave an overview of HST history, originally envisioned as a 15-year mission with a return to Earth via an STS mission. In theory HST should be coming home next year. Alternate end-to-mission scenarios have been considered. A study by MSFC to extend the life of HST by use of an upper stage propulsion system without requiring an additional STS retrieval mission was summarized. Constraints on the evaluation were summarized, including use of the existing budget as the basis for cost estimates. As a goal, the overall mission reliability should be equivalent to the STS retrieval mission. A foreign-developed propulsion stage can be considered, as well as modification of the current inventory of US upper stages. In view of the changing environment, retrieval is no longer an option. A management decision has been made not to dispose of HST in higher orbit (it must be lifted to 2500 nautical miles above Earth, and this is problematic due to the size of the upper stage required to do this). No existing stages meet the needs of the mission. Propulsive forces are too high. Existing docking system (Russian) forces are too high. The cost is high and availability is difficult to ensure. Existing stages are not configured for rendezvous and STS stages no longer exist. Conclusions are that any options range in cost from $250-300M. The Code SZ position is that HST can be safely de-orbited by an add-on stage, and may be operable after installation of such a stage. The de-orbit stage can be installed with an STS mission, and may be installed with an ELV. Code SZ is convinced that proceeding with an-ELV launched de-orbit stage is the prudent engineering and management position- it allows more development time for the stage and guarantees multiple options in the event of mission failure. It can be converted to STS configuration more easily than the reverse situation. It also decouples cost and manifesting from the HST and STS issues. An envisioned plan would position an RFI after the beginning of 2004, determine the best way to acquire the system, and try to perform SM4 in mid 2005 to 2006, with the worst case scenario being 2009.

Lunch discussion

Presenters remained for a lunch discussion. In response to a question from Dr. Heckman, Mr. Moore explained that $300M included some money for the adaptation of the planned autonomous rendezvous and capture system that has been in development for quite some time. There may be some additional costs associated with HST-unique applications. The primary question is the degree of autonomy for the system. Other engineers may have motivations for autonomy different from HST. If the reboost in SM4 were not successful, HST could have an uncontrolled re-entry in the timeframe of 2013-15 (2 sigma worst case; the expected re-entry date for standard solar cycle is closer to 2020). If a reboost were successful, an uncontrolled re-entry would occur around 2025. Mr. Moore explained that NASA must guard against uncertainties around SM4; contingencies are needed to protect against the worst-case scenario, which would be no SM4. There was further discussion of budgetary concerns. Dr. Kinney commented that any additional servicing missions would come out of the code S budget as part of the FCA philosophy. Mr. Moore remarked that if autonomous deorbit works, there may be a market for the product in the satellite industry.

Dr. Traub questioned the ability to de-orbit ISS in light of the prohibitively high projected costs of de-orbiting a substantially smaller craft such as HST, and posited the question of what NASA can learn from this experience. Mr. Moore speculated that ISS would be directed into the Pacific as Mir had been. Current budget figures for HST end-of-life is approximately $137M based on a shuttle retrieval mission: the money is targeted for the ELV upper stage. “Extreme de-orbit” has been considered but rejected in light of the fact that it would be necessary to place assets anywhere on the orbital track, anywhere around the world. Mr. Burch felt that such a scenario is not feasible. Dr. Beckwith commented that the cost of a 5-year operation at an accepted level of risk and reduced science ranges from $78-80M to $300M. Responding to a question concerning the lower limit of the cost, Mr. Burch noted that the costs are bound by processes and standards imposed by the shuttle program concerning payload bay requirements. The limiting factor is the human one and drives the cost. Mr. Burch did not see answers even outside the NASA community and recognized the need to break the HST paradigm. Mr. Moore noted that pre-Columbia discussion became ugly when safety was seen to be compromised: risk is unacceptable. Dr. Kinney averred that de-orbit is an agency issue; it is unacceptable that NASA cause a casualty anywhere on the planet. The agency, if anything, is becoming more conservative in this matter. Mr. Moore noted that ground-track risk is also being scrutinized and will probably become more stringent. Dr. Hillebrand remarked that there are other satellites that will present this problem (in the near to long-term). Mr. Moore responded that NASA (HST) does not have the same options that other satellites have. Dr. Leckrone stated that the odds of human casualty on the ground is 1/700 and is growing dramatically (the standard is 1/10,000). Dr. Richstone commented that extending HST beyond 2010 was not a suggestion from the Decadal Survey (DS) and asked what the driving enthusiasm was for overturning suggestions from the DS. Dr. Beckwith noted that since the survey came out, NASA headquarters as early as 1993 realized that HST could be improved. What they didn’t realize how much space there was to improve HST; they did not take into account the rate of technology improvement. The Bahcall report seemed to suggest that there is value in exploring this extension due to the unknown factors. In response to a question, Mr. Moore stated that if $1.2B were earmarked for an SM5 mission, he would spend the money on HST programs instead of competing (the mission). The question is better addressed to the science community. Dr. Flanagan asked whether Option 2 of the HST/JWST response (including an SM4 propulsion system to be attached for de-orbit) was indeed conceivable? Mr. Moore responded that if the launch date were allowed to float and the EVA schedule was not full, equivalent mass were to be taken off HST, and money was to be found, the mission could be accomplished by 2008-09. This would mean the telescope would be non-operational for a number of years. Mr. Moore continued, saying there is a tremendous cost to the end-product and a risk to the delay, as well as the money factor. Dr. Finn asked at what point in the delay of SM4 does it become reasonable to talk about killing SM4. Dr. Beckwith commented that if HST starts to tumble, that is catastrophic and presents a large engineering problem and asked what the overall loss to science would be with an HST loss. Dr. Beckwith said he would be reluctant to make that decision now unless there were a compelling reason to do so, and believed that a propulsion element could be put on HST without a significant loss of science. However, it is uncertain whether it's credible to develop it in the SM4 timescale. Dr. Leckrone noted that preliminary results indicate that it is feasible to put a propulsion module on HST. Dr. Beckwith commented that aberration mitigations came about in three years and thought the engineers could do it. Mr. Burch commented that the propulsion module does not require a long EVA time (2 hours). There are minor weight and volume swapouts; however the delay to 2009 would be prohibitively expensive. Dr. Dermer noted that he was hearing two different voices that essentially translated to optimism versus pessimism about engineering problems, and asked how determined NASA was to perform an SM4. Mr. Moore replied that the Administration is committed to Return to Flight and wants to return to pre-Columbia status. NASA has an option not to fly; Return to Flight is rightly focused on manned space flight. The impact on HST is time. Dr. Dermer observed that the astronauts were willing to risk more in terms of science and asked about missions that do not have the same human costs. Dr. Leckrone commented that he found it hard to envision replicating HST capabilities in other missions or by ground-based assets. Dr. Beckwith commented that advances in adaptive optics (AO) are projected to be in the near-infrared. If AO works well, it would encroach on JWST first. It is not clear what can be accomplished at a lower cost. Dr. Kolb asked Dr. Kinney to describe the decision process post-meeting. Dr. Kinney replied that the SSAC will meet in mid-November, and that important inputs on HST will be a major item on the agenda. There are implications for reprogramming money from other themes into accomplishing HST objectives. APD is looking for a concise conclusion and would like the subcommittee to weigh in on the proposed plans to complete SM4 and autonomous de-orbit capability. Mr. Moore added that APD needs to be positioned in order to be prepared. If technology improves, it will be used. Dr. Heckman noted that the plan does not follow the advice of the Bahcall committee's suggestion to compete SM5. Dr. Kinney replied that APD made a good faith effort in describing how SM5 might be competed and invited the subcommittee to comment on all the Bahcall suggestions. Dr. Ferguson commented that there is insufficient funding to do the full propulsion module and asked if this was a good use of code S funds. Dr. Kinney replied that this was not quite correct. In preparing for FY06, the division has taken into account the BE probes and SM4, and has the remainder set aside for de-orbit upper stage. Dr. Kinney concluded the discussion by inviting the subcommittee to comment on the science of NASA's plan for HST.

NASA/DOE Joint Dark Energy Mission

Dr. Paul Hertz presented an overview of a proposed NASA/DOE interagency mission to investigate dark energy in the universe, the Joint Dark Energy Mission (JDEM). Both NASA and the Department of Energy (DOE) have identified dark energy as a high-priority area. Dark energy drives all cosmology and makes up 70% of the universe. In partial response to National Academy of Science (NAS) recommendations, they have agreed to plan a space-based mission. If the mission goes forward, it would address the dark energy goals of BE. Principles of cooperation were summarized: NASA should have principal responsibility for space operations. DOE brings to the project its experience with large collaborative projects. A competitive selection is envisioned. The mission would involve a 3-year PI-led investigation, followed by activity at the space-based observatory. A joint AO would be issued to solicit the dark energy science. The mission will be fully costed. A notional organizational chart was presented, headed by a NASA/DOE Joint Oversight Group. A strawman schedule assumes 15 years from start to finish (plus one year pre-phase A), with a projected launch 9 years after budget approval (in 2014, optimistically). The project will be difficult to accomplish quickly because the money is divided and both NASA and DOE will be answering to outside agencies (OMB, Congress). The two different communities will also be a challenge to manage. However there is a positive history- DOE and NASA have worked well together on GLAST and on the Prometheus (nuclear initiative) Project. Near-term next steps include NASA selection of mission concept studies after consultation with DOE. Mid-term steps include establishment of a pre-project office.

The mission concept is a single science team working on the required instrumentation. In response to a question, Dr. Hertz averred that NASA will not run the mission like a SMEX. All the science will be fully competed as a PI-led investigation, however there will be a NASA project manager. Dr. Spergel asked whether the subcommittees should discuss the competition as a potential issue. Dr. Bregman commented that it sounds like an optical or IR mission. Structure seems to increase the risk- few focal plane instruments are awarded to one group and this may not best serve all the instruments; he asked what minimum science requirements would make it worthwhile to do the mission. In response to a question, Dr. Hertz replied that DOE is interested in a stand-alone mission. Dr. Bregman noted that an HST instrument may go up considerably sooner. This issue was identified as a positive area for further discussion by a Dr. turner of DOE. Dr. Green asked why the mission should not be constructed as an Einstein probe. Dr. Hertz replied that from the point of view of the best investment of government resources, it appears to be the best thing to do. A broad suite of areas will be recommended (DOE/NASA/NSF) for interagency cooperation. Mission concept studies will be used by the science definition team (SDT) to set the science requirements, just as it has always been done for missions. How to deliver the science will not be specified. Dr. Richstone expressed concern that during directed missions with long lead times, other events on the ground can overtake and preempt some of the science questions. It is also well known that there is a well-funded DOE effort that has already been working on the program. He continued by commenting that the competition should be genuinely fair and be seen as fair from the community. Dr. Hertz completely agreed with latter point. The former point is a challenge for the community and the SDT.

SEUS session

Subcommittee discussion of JDEM

Dr. Staffin of DOE, in response to a question, stated that he viewed the project as a truly joint mission. Cost overruns, etc, will be dealt with as the mission goes on. Joint oversight and joint accountability are assumed. The problem-solving process will be refined. Dr. Cherry asked for an enumeration of the advantages of a joint project. Dr. Hertz replied that there are inherent advantages to interagency missions. Dr. Staffin noted that while a joint mission may not be easy, but it raises NASA/DOE out of the noise of the proposals. Dr. Hogan commented that some would say ground-based-astronomy (NSF) should be involved. Dr. Hertz replied that the usefulness of LSST is recognized. Dr. Finn noted that from a funding perspective, someone has to have a fiduciary responsibility. Dr. Hertz stated that if the mission fails, NASA would be called to Congress as the agency responsible for launch. Dr. Ulvestad asked if NASA had plans to solicit proposals from the community. Dr. Hertz replied that NASA is examining dark energy proposals at present (from a February solicitation). The project management will be at GSFC. The choice of SDT members will be decided jointly. In response to a question from Dr. Kolb, Dr. Staffin stated that DOE would consider contributing to an installation of a WFC on the HST because DOE has an institutional interest in dark energy. The cost estimate (WAG) is well over $1B, at about a 70-30 split. The mission looks like an optical infrared observatory; nothing else seems to suggest otherwise. If the SDT deems this concept too narrow, the AO would be adjusted to solicit all the potentially valuable methods. All data will be available after an appropriate proprietary period, probably at least a year. The proprietary period would be defined by community input.

HST discussion

Dr. Flanagan opened the discussion by stating the necessity for a response to the Bahcall panel's recommendation. Dr. Finn noted that recommendation #2 also had propulsion module as part of SM4 and reiterated a concern about a propulsion module's potential to interfere with HST science. It seems that the NASA plan is not any one of Bahcall's recommendations, although it is closest to option 2. Dr. Yorke commented that the cost of shuttle launch in 2010 would be considerably inflated by CAIB requirements. The shuttle cost is not included in the $1.2B proposed. The cost was intentionally left out. Dr. Mundy commented that the focus should be on SM4 succeeding. If NASA never does an SM4, it must plan for contingencies; this might be cheaper to do ahead of time instead of embarking on a crash program. It is a good time to ask these questions as the Columbia problem is being discussed. Dr. Cominsky reminded the committee that gyro failures are what doomed the Compton observatory. Dr. Hertz noted that HST has some failsafe gyros. A member commented that the 2013-15 timeframe is really not the issue- the issue is the latest that the HST will be stable, which is projected to occur before 2013. Dr. Wright commented that HST has no thrusters and cannot change its angular momentum; an intervention must be performed before the craft is completely dead. As far as science goes, it is reasonable. However, spending $300M to save (a fractional number of) lives doesn't make sense. Dr. Wright recommended that NASA try to do the intelligent thing in assessing this tradeoff. Dr. Finn commented that the main points are that NASA needs a propulsion module, which is a separate mission and not combinable with new instruments; the propulsion module is not available in the current optimistic timescale, SM4 is tied to STS availability, and if SM4 is delayed, HST can still do good science. SM5 is the elephant in the room. If SM4 is delayed, where is the point where SM4 is no longer reasonable? This must be defined. Dr. Bregman pointed out that Dr. Kinney did say that if HST is frozen, SM4 would not take place. Dr. Kolb stated that it is agreed that SM4 should be done if it can be performed before 2009. Dr. Cominsky commented that it costs $120M/year to maintain the HST servicing capability. Dr. Hertz stated that the costs could be ramped down until SM4 is ready. The subcommittee agreed that SM4 would not be worthwhile doing past a certain point. The aim is to de-orbit HST safely after useful science ceases- the choice here is when the de-orbit must take place. Dr. White commented that there are other missions (such as XTE) that pose an equivalent risk and hazard- there is a double standard and this point should be raised at SScAC. Dr. Wright added that some Russian satellites are in fact real dangers. Dr. Flanagan felt the subcommittee should state that deorbit should not be done before useful science ceases. Dr. Ulvestad objected to the perceived rush to de-orbit. Dr. Mundy commented that it may be just gamesmanship to attempt to get the $300M right away. Dr. Hertz commented that monies earmarked for HST cannot be moved; the great observatories, with their own funding lines, are not part of the Senior Review. That advice comes through the Decadal Survey and the Roadmaps. There was a brief debate about the terms "exciting" versus "useful" science? It was generally agreed that there is a guaranteed negative impact on science about to happen. HST is going to end and will cost $300-500M. OSS is going to expend its own money on a project incapable of doing science. There may be no choice. Installing the propulsion module is the low-technology alternative that would simultaneously allow more instruments. If the SM4 succeeds, HST will last until 2020. If $500M must be inevitably spent it would be worthwhile to try to obtain some science value from the expenditure. Dr. Flanagan commented that the combination of the propulsion module and science will cost more than $500M. The concept of putting the propulsion module on SM4 will actually delay SM4. Dr. Kolb commented that the fundamental plan is to safely de-orbit. Dr. Cherry noted that retrieval by shuttle is off the table. Dr. Hertz added that since Challenger it has been the policy to use the shuttle only when it can't be done any other way (noble activities). There is no way that retrieving HST falls into this category. Dr. Yorke pointed out the difficulties of addressing a moving target; there is no way to predict shuttle capability after Return to Flight. The present plan of starting an ELV de-orbit capability is intelligent- if this is neglected, it may not be possible to safely de-orbit HST. The plan should be inserted into the budget while other options are considered as they develop.

SM5 discussion

Dr. Bregman agreed with Dr. Kinney's contention that SM5 is not viable. Dr. Heckman endorsed the Bahcall committee's idea of having peer review of an SM5 concept. Dr. Wright commented that if an SM5 is flown, it will cost $800M, which translates to a total of $1.8B for prolonged HST operation. Dr. Heckman suggested letting the community decide on the scientific merit of an SM5. Dr. Wright noted that one might argue that Bahcall had a conflict of interest. Dr. Heckman replied that one might argue that the subcommittee has more conflicts. Dr. Flanagan argued that the numbers given to the Bahcall committee were too low- it would be destructive to displace many years of Explorer missions with this one problem. $1.2 B is the cost of a facility-class mission that should come through the community and Roadmaps. It would not be a fair competition. Dr. Hertz replied that the concept is not to look at SM5 versus Explorer programs- the only things competing for this money would be real proposals- the concept is to abandon a Discovery mission or an Explorer mission for a scientifically viable concept. Dr. Finn suggested examining the Bahcall recommendations in light of all the engineering results heard at the meeting and the practical issues they imply. Dr. Hogan felt that the decision to drop an SM5 mission is a bold one, but that there is still a lot of uncertainty; a way must be found to coordinate HST operations with the NASA roadmap process. The subcommittee might suggest a middle of the road way to address this and keep it alive a little longer. Dr. Hertz noted that NASA would have to spend money now only if new instruments were proposed for SM5.

The overall cost is unknown and could be as high as $2.2B; Dr. Yorke proposed delaying the decision as long as possible. Dr. White commented that this process is divisive- it is worth remembering that JWST was sold on the idea that SM4 would be the last HST mission. If SM5 were to go forward, new money must be appropriated. HST is an Origins program and must be pursued in that context. Origins should be encouraged to issue an AO that might include Origins probes and new instruments. Dr. Kolb asked whether the subcommittee should support Kinney's proposal or Bahcall's option 1. Dr. Dermer preferred Dr. Kinney's proposal: support boosting HST with SM4 and not competing an SM5 mission. Dr. Yorke voted against financing SM5 at the expense of Discovery/Explorer missions. Dr. Finn endorsed Dr. Kinney's plan. Dr. Flanagan stated that she was opposed to setting up a competition for such a large amount of money because it rewards an unorthodox process for displacing programs. The subcommittee should make a strong statement to assuage the concerns of the community. Dr. Heckman stated that HST is the single most positive NASA program and it is therefore hard to weigh it against other programs. Information at present is also incomplete and insufficient to make irrevocable decisions about autonomous retrieval and docking systems. Dr. Heckman endorsed beginning the process of the competition in the way envisioned by Bahcall's committee. Dr. White endorsed Dr. Kinney's plan, stating the competition would drive away the Explorer missions, never to return. Dr. Mundy suggested postponing the decision by throwing it back to Origins; there needs to be a good science case for future HST science, and there needs to be new money. Dr. Bregman endorsed the value of the Explorer and Discovery lines and stated that with SM5, NASA is being asked very quickly to assess a large program without a clear science return. There is too much risk associated with Return to Flight activities, and furthermore, the 70s level of HST technology must be allowed to advance. NASA can build a great free-flyer as good or better than SM5, therefore supporting Dr. Kinney's proposal. Dr. Ulvestad commented that it was difficult to see how there could be a fair and open competition in such a short time and endorsed the idea of looking at a new Origins line, thus endorsing Dr. Kinney's plan. Dr. Cherry noted that at the last meeting the subcommittee debated revamping the Explorer program and decided to keep a healthy contribution from small programs. Dr. Hogan suggested keeping it alive a little longer; compete a little bit because "not compete" means stop. Dr. Wright noted that the HST is very expensive to run due in large part to shuttle costs; there is a large impact of servicing the HST for little science. Dr. Wright was against closing down the Explorer and Discovery lines. Dr. Cominsky endorsed Dr. Kinney's plan; the community needs Explorer and Discovery to train the next generation of scientists. Writing large proposals also sucks valuable energy out of the community's research efforts. Asking for new money will result in an unfunded mandate.

Dr. Kolb briefly summarized the discussion in three bulleted statements:

- The committee supports the plan for SM4 in a viable timeframe
- understands the political and technical reasons to study ELV but is concerned about the rush to completion
- feels there is near-consensus on not competing new instruments for an SM5 mission as proposed in the Bahcall transition report.

A question was put to Mr. Mike Moore about driving the requirements for the ELV. Mr. Moore explained that the idea is to have concepts in hand and acquisition plans in place just in case there is an acute problem. NASA does not have to spend $400M in three years or at an accelerated rate. Experience dictates that it always takes longer than expected to develop a solution. NASA must be ready for a 5-year development program, which takes some preliminary expenditure. NASA is going to buy a system that is capable of flying on an ELV, however it can always be transitioned to a shuttle. Phasing changes can be made but the path will stay the same.

<u>SEU Update including Beyond Einstein</u>

Dr. Hertz briefly addressed the scheduling of the next SEUS meeting, which will probably be in Cocoa Beach, FL in late February or March. Roadmapping will also start in the middle of next summer, and is another idea to start mulling over.

Dr. Hertz presented aspects of the BE program. GP-B is coded yellow due to some mission challenges: two of the gyros are experiencing noise at levels that are above specifications. The decision to launch with noisy gyros aboard depends on the root causes and on the solution. There are also a number of open items (4 times as many as expected). Open items include RFAs from peer review teams and new software change requests. Dr. Hertz was unsure whether launch delays would mean termination. Launch approval would not be given if thermal vacuum requirements and contingency plans were not met. Swift is red and is still losing a bit of schedule, and there is a thermal vacuum testing conflict with the MESSENGER mission that has not been resolved yet. AstroE2 is red due to a leak in a dewar; double-shifts are currently in place to find it. This may cause AstroE2 to lose its launch date, which could result in a multiyear launch slip. GLAST is now green. It overcame some interesting catch-22s on its de-orbiting issues. The mission went to Ku band for communications, removing dependence on commercial downlinks. Herschel is green, having solved its problems with funding allocations taken from other programs. LISA is green. It should be noted that ESA is oversubscribed by 50% and may cancel or defer missions. LISA may be impacted; however LISA has been strongly endorsed and will probably stay in the program. Constellation-X is green. Planck is yellow due to concern over cryocooler lifetime, but NASA remains highly committed to the mission. Senior Review will take place in April 27-30, 2004, for SEU and Origins missions. Participants in the Senior Review were listed.

Beyond Einstein
BE is not a funded NASA program until Congress passes the budget. BE is in both mark-ups. High-profile outreach activities such as Cosmic Questions opened recently in Washington DC. A BE Program Office has been formed at GSFC. BE will enter phase A as soon as the budget is approved. Proposals for Einstein Probe mission concept studies have been received and selection is imminent. Dr. Bregman expressed concern that the best science would not be selected in favor of trying to win the proposal. Dr. Hertz allowed that there must be tension between science and practicality. Mission concept study results should be announced in a month. Inflation Probe will need a technology development program that will be helped along by a joint NSF/NASA roadmapping activity. The Einstein Great Observatories will take the highest priority. E&PO activities were summarized. The E&PO director for BE, Dr. Paul DeMinco made some brief comments on the ramp-up of these activities. Target audiences are community colleges and NASA is also looking at the middle school area. Education and outreach seeks to involve more people in evaluating goals and objectives in the longer term. There is much work to do to prepare secondary school teachers for the BE concept. Standards alignment issues will follow the lead of OSS in developing a framework initiative to address education curriculum standards and AAAS standards. Dr. Cominsky endorsed quick planning for outreach to allow the public to become comfortable with Einstein, and to try to take advantage of the AIP's effort to promote the Einstein Centennial (of Special Relativity) in 2005.

Code R: Enabling Concepts and Technologies Program NRAs
Twenty-four of 111 tasks funded are of high interest to SEU; among these are ultra-reliable power generation and storage technologies, as well as 16 sensors. Information technology is being funded at $200M per year. It is important to make Code R aware of SEU requirements. Code R can assist with interoperability of archives, lights-out operations during extended missions, etc. The subcommittee was assured that translation of science needs into IT requirements was being facilitated by Harley Thronson's office. It was recognized that there is still a disconnect between industry and NASA in developing or commercializing these technologies.

October 24, 2003-Joint SEUS/OS Session
Project Prometheus
Mr. Alan Newhouse, director of Project Prometheus, presented an update on activities. The project was begun as a nuclear systems initiative to address power and propulsion needs of the space science program. The Administrator is committed to the program to develop radioisotope-based heaters and power units and, in particular, fission power systems. These systems are targeted to travel beyond Mars, where solar flux is insufficient to provide a propulsion or power source. Reaching and investigating the Outer Planets will require nuclear power. The project is developing RPS units that could be used for Mars Smart Landers and Scouts. Safety is a paramount issue. DOE remains the regulatory authority for the development of nuclear systems, however NASA HQ is responsible for science, mission, and proposal selection, advanced planning and program control. The Presidential Launch Approval process requires an independent review before each launch carrying nuclear devices. The Cassini-Huygens probe arriving at Saturn's moon, Titan, in July 2004 is expected to generate even more interest in the exploration of the outer solar system and hence the nuclear initiative. The objective is to provide what the community wants, thus the Project is looking forward to opening a dialogue to determine these needs. By the end of the decade, the Project would like to provide space science mission planners with small thermoelectric-based nuclear power sources [MMRTG] capable of operating in space. Stirling radioisotope generators (SRGs) are also in development for

providing power (120 W) for scientific instruments. Plutonium 238 is currently being purchased from Russia, however DOE is looking to resume limited production in the future. As higher efficiency units are developed, less plutonium will be necessary to power them. Potential RPS-powered missions are the solar probe, systems to provide extended rover life and range on Mars, Mars sample return, a single-pass flyby of the Pluto-Chiron system. The Jupiter Icy Moons Orbiter (JIMO) is a fission reactor powered system. JIMO supports the decadal survey goal of exploring Europa; it will enable global reconnaissance of Ganymede and Callisto as well. Mass and power requirements for potential missions were briefly discussed. It was noted that 75 kg of Pu was needed to produce 900 W of power- most of the energy is released as heat. Total mass for the fission powered 100 KWe JIMO craft is estimated at 22,000 kg. Costing has not been done yet. To produce the power envisioned for missions (10 kW is about the breakpoint), the Project scientists feel that NASA can still do an 800 W mission with radioisotopes. 20kW would require a reactor. Small reactors [<10 KW] are not efficient for space; there is a minimum mass to make a reactor operate. Electric propulsion augmented with solar power, or chemical propulsion, are other alternatives. Electric propulsion has been demonstrated by the Deep Space 1 spacecraft. Project Prometheus is actively engaging environmentalists and nuclear activists to gauge opinion, and is also soliciting feedback from anti-nuclear activists.

APWG Report

Dr. Douglas Richstone presented a short briefing to raise an issue of concern in R&A. There is a mandated stovepiping of R&A activities under the respective themes, which has the potential to straitjacket all R&A. The implications are potentially serious for proposers. If someone wants to make a theory proposal, there is danger they would be told that their interest fell not under SEU but Origins, to cite one example. APWG is very worried about this, and would recommend to SEU and OS to put the problem on the SScAC agenda. The ASO theme holds hands with planetary science and may have a similar issue. Dr. Richstone promised to produce a paragraph delineating the finer points of the issue within a week. Dr. Kolb asked who the target audience should be. Dr. Crane noted the stovepiping was contrary to what SScAC asked NASA to do 5 years ago and warned that in time the practice will become ossified. The directive originally came from Code B. There was general agreement that stovepiping was an unwise organizational strategy.

JWST Mission Update

Dr. John Mather presented an overview of JWST. Since a replanning exercise a year ago, the program has been on an even keel, having partnered with ESA and CSA. The mission lead is located at GSFC. The telescope mirror is now 25 square meters (each hexagonal element is about one meter in size) to be launched by an Ariane 5 in Kourou in French Guiana, with a launch timeframe late in 2011. Mission success criteria have been finished, which include measurement of the space density of galaxies to a flux density limit, measurement of at least 2500 galaxies with spectral resolutions of approximately 100 (0.5 to 6 microns) and 1000 (over 1 to 5 microns) and to a 2 micron emission line flux, measurement of the physical and chemical properties of young stellar objects, and enabling, within a 5-year mission, a total observing time of at least 1.1×10^8 seconds on targets located at any position on the celestial sphere. An instrument overview was presented as well as the configuration of the craft. Recent accomplishments include making a choice on mirror segmentation (18 hexagons), selecting a Be mirror, a 5-year lifetime cryostat (dewar), completing an independent cost estimate, and beginning phase B (detailed design) following an MDR and ICR. The current cost is estimated at $1.6B, a target that must be maintained (and does not include ESA and CSA contributions). Level 1 requirements have been finalized. A design change has been made in NIRSpec - ie, have reduced pixel count and increased the pixel angular size for NIRSpec, effectively yielding better efficiency. The differences in performance between Be and ULE glass were shown; the ULE is more non-uniform than the Be at cryocooled temperatures. The mirror is expected to be almost as good as the Hubble mirror but the segmented system has many other sources of wavefront errors. Detector technology development is expected to be at TRL-6 in March 2005. Specificaions have been achieved for read noise and dark current, translating to very good detector technology, better than what is flying on SIRTF. Microshutter test units were shown. ESA has been asked to carry a backup technology, which is not as good as the US product. Plans for phase B include System Requirement Reviews (SRRs) for MIRI and NIRCam, an Observatory SRR, and an Ariane interface definition. The finalized de-scope plan is bare bones- further de-scopes would interfere with level 1 requirements. Dr. Bregman asked how the mission will deal with future changes in detector technology. Dr. Mather replied that he expected improvements in read noise and dark current and will retrofit improved detectors if possible. The Cryostat is expected to have at least a 50% margin on the final lifetime estimate. Dr. Ferguson expressed concern about mirrors and asked for the significance of the RMS numbers. Dr. Mather replied that they are the differences between room temperature and cold (about 25 nm uncertainty- a tour de force, in fact). The biggest worry thus far is testing the whole system. Dr. Ulvestad remarked that other great observatories have taken an average of 16 years from instrument AO to launch. Dr. Mather did not envision significant delay beyond 2011. Dr. Eric Smith commented that 16% of the budget has already been spent on JWST technology to buy down the risk.

SEUS Session

The Swift GRB MIDEX Mission

Dr. Neil Gehrels presented some challenges present in the Swift mission. The launch date has slipped to May 2004 from September 2003. There is a temporary conflict with the MESSENGER mission over use of a thermal vacuum testing facility that could cause an additional one-month delay. A harness was modified to solve a communication problem with the BAT (Burst Alert Telescope), which also contributed to the delay. The remaining instruments are already on the spacecraft. Swift will be flying all the instruments proposed at their full capability. GSFC is the managing institution and Penn State is the site of the missions operations center (MOC). Gamma ray bursts (GRBs) are the ultimate SEU phenomenon; they are the most powerful explosions in the universe, the birth sites of black holes, ultra-relativistic outflows, seem to be related to hypernovae, and may be used as probes of the early universe. Science questions include: What causes them, what is the nature of their subclasses, what physics can be learned about black holes and outflow? The three instruments on Swift are the BAT, the most powerful and sensitive gamma ray detector ever flown, an x-ray telescope (XRT), and a UV/Optical Telescope (a close copy of the monitor on XMM). The primary objective is to get the XRT and UVOT to the source of the GRB while the afterglow is still strong. Mission capabilities were summarized. Multiwavelength observations start within one minute of a burst and continue for days. The mission hopes to follow up 80% of an expected more than 100 localizable bursts per year. The craft will autonomously point to a new burst to perform follow-up observations; the mission team is developing an algorithm to prioritize the decision of what GRBs to follow up. Swift will be capable of following up bursts seen by GLAST via communication through the GRB coordinate network (GCN). Rapid GRB notification will be made through the GCN to distribute information for additional follow-up activities in radio and IR wavelengths. Results will be on the Internet in about 20 seconds. Swift science topics include investigation of short burst GRBs (which tend to be harder than the long bursts), the supernovae-GRB connection (the role of spin in stellar evolution), and early universe (detecting bursts at high redshift). Swift may be a unique probe of Population III stars (first light in the universe) and the epoch of reionization. Swift status was briefly recapitulated: XRT and UVOT were delivered to the craft in Nov-Dec 2002; observatory testing and science simulations are under way, and funding is in place in the UK and Italy for post-launch support. A Swift topical session was held at AAS/Nashville in May 2003. Data dissemination will occur as quickly as possible. Some of the non-Swift correlated data will be archived in the IPAC by others in the community and perhaps in the HEASARC. Dr. White noted that data need to be archived in a usable form. Proposals for the Guest Investigator program are due on December 1. Sixty-seven notices of intent have been received and $1M in grants are to be awarded in cycle 1. The program will fund 30 investigators at $30K apiece. A scientist will be assigned to each burst; their roles govern data product, web updates, and outreach to the follow-up community. There are no current international agreement issues associated with the recent change in the Italian government, however there is a USN backup if Malindi disappears.

HETE Mission Update

Dr. Hertz briefly commented on the rationale for the presentation. HETE was not on the Senior Review (SR) 2004 because its funding stops in January. HETE has proposed an extension of its mission to preserve overlap with Swift. If HETE is extended, NASA will have to find the money somewhere, decreasing funds for some other operating mission. Dr. Hertz invited comments from the subcommittee on the proposed extension, which would cost about $900K.

Dr. Kolb recused himself from the discussion because the University of Chicago is a co-investigator institution in the HETE project. The HETE discussion was chaired by Dr. Hogan.

Dr. George Ricker presented the mission update. HETE is comprised of a gamma ray telescope (FREGATE) , a wide field X-ray monitor, and a soft X-ray camera (SXC). The 2000 and 2002 Senior Reviews (SR) have recommended overlap with Swift. In the past 1.5 years, HETE has continued to produce outstanding science, the Swift launch has slipped, and it has become clear that a HETE-Swift partnership would enhance the science of Swift. HETE localizes about 25 GRBs per year. Twenty-one have led to detection of an x-ray, optical or radio afterglow. Redshifts have been reported for 12 HETE-localized GRBs. Six major science insights gained in the last 18 months were presented, including detection of an extreme case of an x-ray flash, a refreshed shock (inhomogeneous jet), and several bursts that would likely have been classified as optically dark bursts were it not for the localizations provided by HETE. A supernovae/GRB was also discovered; HETE detected the GRB and 7-8 days later, optical observations detected a supernova spectrum in the afterglow. The x-ray flash work cannot be done with Swift. HETE and Swift working in partnership would approximately double the number of rare bright GRB events that would be detected by Swift alone. HETE is also able to disseminate detections quickly for optical follow-up- 7 localizations were made available in less than 60 seconds in the last 18 months; others have been made available within hours. The soft x-ray camera has had problems but they have been rectified; all of the SXC results were too late for inclusion in the SR 2002. In the past year, most bursts have not been optically dark. X-ray flashes (XRFs) and GRBs were briefly compared: spectral peaks in x-rays versus spectral peaks in gamma rays, respectively, are the principal discriminators. The nature of XRFs is largely unknown. HETE-discovered XRFs may provide unique insights into GRB rate, the structure of GRB jets, and possible links to supernovae. HETE results confirm and extend the Amati relationship. GRBs can provide an empirical predictive redshift estimator that is accurate to approximately a factor of 2. HETE is also ideally suited to localize and study XRFs, a compelling reason to continue HETE during the Swift mission. HETE synergies were summarized and conclusions presented. Eight XRFs have been seen in the last 6 months. Dr. Finn commented that an important part of the proposal involves Swift follow-up and asked how Swift will follow up HETE triggers. Dr. Ricker replied that Swift has the capability to do this almost immediately, but discussions continue; the added delay is probably tens of seconds. HETE triggers (always in an anti-sun direction) cover a different area of the sky than does Swift, meaning that slews for HETE triggers would put a heavier demand on slewing for Swift. This is not a concern because triggers will not happen that frequently. Dr. Mundy noted that the overlap is the strongest argument for continuation and that the HETE organization will fall apart without funding.

Discussion of recommendations and findings

Members resumed discussion on recommendations and findings. Dr. Flanagan led a brief discussion to consolidate issues raised by presentations. Members in general declined to endorse recommendation 1 from the Bahcall report, but did support the concept of beginning work on an ELV propulsion module. It was remarked that the Bahcall report should be taken seriously but read in the context of the last two decadal surveys (DSs). The last DS endorsed a high rate of Explorer/Discovery missions, a seeming contradiction to the Bahcall recommendation. A fair and open peer competition could be accomplished only with great difficulty. It may be good to have a vision concept study AO for Origins probes (unfunded at this point) to compete against an SM5, attracting new funds perhaps for Origins. Concerns were raised about the impact of ignoring the Bahcall recommendation- there could be a great deal of controversy if NASA were seen as dismissing an SM5 concept. Dr. Wright noted that a proposal preparation effort would be too expensive. Dr. Hogan suggested that NASA avoid distracting the community with SM5 because JWST is going so well. Dr. Bregman commented that if SM5 could do dark energy better than a Discovery class mission, it should be done.

Dr. Bregman noted that HETE is doing well and that a few additional bright bursts and XRFs might be worth reviewing. Continuation of HETE could also galvanize optical support groups and keep them on track, allowing continuity in the follow-up community. Dr. Dermer added that there may also be unusual bursts that could be captured by HETE’s extended operation. Additional science can also be accomplished with follow-up. Operations costs for Swift amount to $4M per year, excluding the GI program. Dr. Mundy warned against preempting the judging process and suggested that the expert panel make the decision. Dr. Ulvestad mentioned that he had seen 7 Chandra TOO follow-ups and asked how much they had cost. Dr. Hertz replied that some fraction of these TOOs were peer-reviewed and some were done on the director’s discretionary time. Dr. Finn suggested considering the continuing operations during the overlap period (does it meet the intent of SR 2002?) and making inclusion in the SR 2004 a separate issue. Dr. Hertz emphasized that the decision hinges on the peer review and revolves around the science value of the extension. Dr. Cominsky noted that it is unprecedented to turn off a functioning craft while it is performing well. In addition, the Swift launch is not guaranteed, in itself another argument for extension. The charge to the reviewers did not include the SR question but many reviewers addressed it anyway. Dr. Heckman endorsed the peer review process. There was general agreement that HETE should be extended.

APWG stovepiping concerns-
Dr. Hertz noted that the entire agency is budgeted by theme, and that the divisions prefer to pick the best proposals that meet the R&A objectives and avoid moving the money around. Dr. White commented that Explorer is run out of the Sun-Earth Connection (SEC), but Astrophysics has nonetheless been able to get missions. Dr. Dermer commented that the real problem isn't stovepiping, but rather the low level of Theory funding in general. Dr. Cherry agreed that this is a problem for the entire R&A program. Dr. Kolb observed that everyone on the SScAC is sympathetic to getting more R&A. The administration reduced money for Theory by $5M last year. A suggested finding was that the program should support the science objective regardless of theme.

JWST-
Dr. Hogan commended the astonishing progress in the JWST mission. Dr. Bregman noted that it seemed to be problem-free, which had not been the case in the past. Subcommittee members took note that the mission had been de-scoped as much as possible.

JDEM-
Dr. Cominsky commented that the plan to have the science team retain all data for the first 3 years while excluding all guest observers (GOs) is not a good idea; it should be mixed with GO proposals from the very beginning. It would be criminal to lock up all that data. Dr. Hertz replied that only the dark energy data would be proprietary. There was also general discomfort with the definition of appropriate proprietary times. A shorter proprietary period was encouraged. Dr. Hogan observed that open data sharing is the future. Dr. Hertz commented that a more generic problem is synoptic data: if the mission releases every data point when taken, longer term searches are jeopardized and the probability of false positives increases. Dr. Bregman suggested the GO program have an early start to iron out the kinks in early data gathering and instrumentation; some good ideas may come out of it. Dr. Hertz noted that JDEM is not yet a funded mission. Dr. Bregman also suggested data releases every 6-12 months. In response to a question, Dr. Hertz explained that the SDT will have some idea what the mission will look like and will be considering AO requirements for yielding a mission worth doing. So far it has leaned in a coherent direction, which appears to be an optical IR telescope. NASA received no studies for anything other than optical IR telescopes. Dr. Hogan commented that there is already a grass roots movement advocating LSST utility in studying dark energy. The general recommendation was to nonspecifically endorse interagency coordination. Dr. White felt that NSF would bring too many complications and not enough money, and suggested a more specific finding to be formulated at the next SEUS meeting. For now a bland interagency endorsement would be preferable. Dr. Mundy suggested these discussions set the groundwork for future missions with DOE. Dr. Hertz solicited opinions on the potential need for a dedicated satellite to study dark energy. There appears to be community viewpoint that HST can't do the job. Dr. Bregman commented that HST will go deeper but it doesn't need to go deeper. Dr. Finn noted that the Black report did not address the issue directly and expressed discomfort about twisting it toward a particular mission. Dr. Bregman suggested a serious consideration of the HST SM5 proposal. Dr. Hertz assured the subcommittee that he would task the SDT to weigh the issue. Dr. Kolb felt the JDEM matter was not an action item for SScAC. Dr. Hogan felt that there should be an action item on the data recommendation. Dr. Kolb endorsed a statement to SScAC affirming the idea of early and frequent data releases.

HST transition-
Members reviewed and discussed a draft of the findings and recommendations on the HST transition. Dr. Heckman observed that the center of gravity is more in the OS court and that SEUS should ensure its recommendations be consistent with OS's scenario. Dr. Hogan suggested considering SM5 only through the strategic planning process. Dr. Kolb stated that true competition should come about through strategic planning and consensus. It was generally agreed that extending HST would interfere with JWST. Dr. Cominsky suggested the subcommittee object to potential interference with the Explorer/Discovery class.

Dr. Wright commented that gyros could fail on consecutive days and therefore statement on the function of HST on 2 gyros should be qualified. Dr. Cherry observed there may be an argument to delay the development of a propulsion module. Dr. Finn remarked that the true urgency for module development will become clearer when Return to Flight activities are clear. Dr. White remarked that the development of SM4 would be useful for de-orbiting other assets as well and may be worth as an augmentation.

Desired presentations for the next meeting were enumerated, including Outreach activities for Beyond Einstein, technology update, LISA, Con-X and SIRTF, the roadmap process, planning for the Einstein Centennial in 2005, and possible joint concerns with OS. Other potential discussion points were the FY05 budget, the upcoming interagency report from the Office of Science and Technology Policy (OSTP), DOE science roadmaps and strategic plans, SUVO, division mission reports, future far infrared concepts, code N, and balloons/sounding rockets.

Overview of SEU research at GSFC

In preparation for a tour of the flight center, Dr. Nicholas White, Chief of High Energy Astrophysics, gave a brief presentation on research activities at GSFC. He presented research themes centering on instruments residing in decades-long development pathways, such as the micro-calorimeter arrays. These arrays will become the workhorse of x-ray astronomy. The current micro-calorimeters are improved versions of those that were lost in Astro-E. Novel efforts are under way to obtain stiffer substrates (glass) for the Con-X optics payload.

The meeting was adjourned.

Appendix A

STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE (SEUS)
October 23-24, 2003

Inn and Conference Center, University of Maryland
College Park, MD

AGENDA

Thursday October 23

Joint Session

8:30	R. Kolb, D. Spergel	Introductions, logistics, procedures
8:40	A. Diaz	Welcome
8:45	A. Kinney	A&P Update
9:15	A. Kinney	NASA Response to HST-JWST Transition Report
9:45	Break	
10:00	Subcommittees	Discussion
10:30	D. Leckrone	HST Science from Servicing Mission 4
10:50	P. Burch	HST Servicing Mission Cost and Risk
11:35	S. Beckwith	Extending HST Science without Servicing
11:55	M. Moore	HST Propulsion Module Studies
12:15		Working Lunch
1:00	Subcommittees	Discussion
2:00	P. Hertz, R. Staffin	NASA/DOE Joint Dark Energy Mission
2:30		Break
2:45		Resume separate sessions

SEUS Session

2:45	Subcommittee	Discussion
3:30	P. Hertz	SEU Update including Beyond Einstein
4:30	Subcommittee	Discussion
6:00		Adjourn for day

Friday October 24

Joint Session

8:30	A. Newhouse	Project Prometheus
9:15	J. Mather	JWST Mission Update
10:00		Break
10:15		Resume separate sessions

SEUS Session

10:15	N. Gehrels	Swift Mission Update
11:00	G. Ricker	HETE Mission Update
11:30	All	Discussion
12:00		Lunch
1:00	R. Kolb, Subcommittee	Discussion/prepare report
2:00	R. Kolb, A. Kinney	Present report to Director
2:30	N. White	Overview of SEU at GSFC
3:00		Adjourn

Appendix B

STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE (SEUS))

MEMBERSHIP LIST

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Note: Expiration Dates in Bold

Appendix C

STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE (SEUS)
October 23-24, 2003
Inn and Conference Center, University of Maryland, College Park, MD

MEETING ATTENDEES

Subcommittee Members:	
Kolb, Edward "Rocky" *(Chair)*	Fermi National Accelerator Laboratory
Bregman, Joel	University of Michigan
Cherry, Michael	Louisiana State University
Cominsky, Lynn	Sonoma State University
Dermer, Charles	Naval Research Laboratory
Finn, Lee Samuel	Pennsylvania State University
Flanagan, Kathryn	Massachusetts Institute of Technology
Heckman, Timothy	The Johns Hopkins University
Hertz, Paul *(Executive Secretary)*	NASA Headquarters
Hogan, Craig	University of Washington
Mundy, Lee	University of Maryland
Ulvestad, James	National Radio Astronomy Observatory
Wright, Edward	University of California, Los Angeles
White, Nicholas	NASA/Goddard Space Flight Center
Yorke, Harold	NASA/Jet Propulsion Laboratory
NASA Attendees:	
Allen, Marc	NASA Headquarters
Barbier, Louis	NASA/GSFC
Bennett, Charles	NASA/GSFC
Breckinridge, Jim	NASA/JPL
Burch, Preston	NASA/GSFC
Coulter, Dan	NASA/JPL
Crane, Philippe	NASA Headquarters
DeMinco, Paul	NASA/GSFC
Devirian, Mike	NASA/JPL
Gardner, John	NASA/GSFC
Gehrels, Neil	NASA/GSFC
Geithner, Paul	NASA Headquarters
Goodman, Gloria	NASA/GSFC
Hasan, Hashima	NASA Headquarters (OS Executive Secretary)
Hollebeke, Debbie	NASA Headquarters
Hayes, Jeffrey	NASA Headquarters
Horowitz, Steve	NASA Headquarters
Howard, Rick	NASA Headquarters
Kaluzienski, Lou	NASA Headquarters
Kelley, Richard	NASA/GSFC
King, Rick	NASA/GSFC
Kinney, Anne	NASA Headquarters
Kimble, Randy	NASA/GSFC
Kniffen, Donald	NASA Headquarters
Leisawitz, David	NASA/GSFC
Leck, Renee	NASA Headquarters
Leckrone, David	NASA/GSFC
Martin, Gary	NASA Headquarters
Mather, John	NASA/GSFC

Meadows, Vikki	NASA/JPL
Moore, Michael	NASA Headquarters
Norris, Marian	NASA Headquarters
Neidner, Malcolm	NASA/GSFC
Newhouse, Alan	NASA Headquarters
Oegerle, William	NASA/GSFC (OS member)
Ormes, Jonathan	NASA/GSFC
Ruitberg, Edward	NASA/GSFC
Savinell, Chris	NASA Headquarters
Schwartz, P.C.	NASA/GSFC
Six, Frank	NASA/MSFC
Smale, Alan	NASA Headquarters
Smith, Eric	NASA Headquarters
Streitmatter, Robert	NASA/GSFC
Trotta, Ann Marie	NASA Headquarters
Tsvetanov, Zlatan	NASA Headquarters
Van Zyl, Jacob	NASA/JPL

Other Attendees:

Baltay, Charles	Yale University
Beckwith, Steven	Space Telescope Science Institute
Beres, Kathleen	Orbital
Cheng, Ed	Analytical Concepts
Doxsey, Rodger	Space Telescope Science Institute
Deustua, Susana	AAS
Ferguson, Henry	Space Telescope Science Institute (OS member)
Frank, Donald	Titan Corporation
Gilman, Fred	Carnegie Mellon University
Griffiths, Richard	Carnegie Mellon University
Green, James	University of Colorado (OS member)
Helou, George	California Institute of Technology (OS member)
Herman, Dan	Brashear
Hillenbrand, Lynne	California Institute of Technology (OS member)
Kaminski, Amy	Office of Management and Budget
Kim, Helen	Moore Foundation
Kopplin, John	Spectrum Astro
Lillie, Charles	Northrop Grumman
Limon, Peter	Fermilab
Margon. Bruce	Space Telescope Science Institute
Malay, John	Lockheed Martin
Morse, John	Arizona State University
Norman, Colin	The Johns Hopkins University (OS member)
Oluseyi, Hakeem	Moore Foundation
Purdy, William	Ball Aerospace
Rainey, Patricia	Boeing
Richstone, Douglas	University of Michigan (OS member)
Reichhardt, Tony	Nature Magazine
Saha, Abhijit	National Optical Astronomy Observatories (OS member)
Siegrist, Jim	UC Berkeley
Spergel, David	Princeton University (OS Chair)
Staffin, Robin	Department of Energy
Thompson, Steve	Spectrum Astro
Traub, Wesley	Harvard-Smithsonian Center for Astrophysics (OS member)
Turner, Kathy	Department of Energy
Weinberger, Alycia	Carnegie Institution of Washington (OS member)
Woodruff, Bob	Lockheed Martin

Appendix D

STRUCTURE AND EVOLUTION OF THE UNIVERSE SUBCOMMITTEE (SEUS)
October 23-24, 2003
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LIST OF PRESENTATIONS

1) Dr. Anne L. Kinney; *Astronomy and Physics Division Overview*
2) Dr. Anne L. Kinney; *HST Lifetime and End-of-Mission Scenarios*
3) Dr. David Leckrone; *The Scientific Rationale for HST Servicing Mission 4*
4) Mr. Preston Burch; *HST Servicing Mission 5 Cost and Risk*
5) Dr. Steve Beckwith; *Hubble Science Without Servicing*
6) Mr. Michael Moore; *Alternate End-of-Mission Concepts*
7) Dr. Paul Hertz, Dr. Robin Staffin; *NASA-DOE Joint Dark Energy Mission*
8) Dr. Paul Hertz; *SEU Theme Update including Beyond Einstein*
9) Mr. Alan Newhouse; *Project Prometheus, Revolutionizing Solar System Exploration*
10) Dr. John Mather; *JWST Project Update*
11) Dr. Neil Gehrels; *The Swift GRB MIDEX Mission*
12) Dr. George Ricker; *HETE Mission Update: Status and Scientific Highlights*
13) Dr. Nicholas White; *Overview of SEU Research at GSFC*